Sustainable housing as part of sustainable development - visions and experiences from Denmark

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Introduction

The paper discusses different approaches to sustainable development with main focus on sustainable housing, but also local climate activities with focus on transportation, food and local businesses are discussed. The focus in the paper is mainly on experiences from Denmark.

The paper starts out with a short introduction to theoretical approaches to analyses of sustainable housing and other sustainability initiatives as innovation processes. Afterwards some social and political characteristics of Denmark are presented and one of the recent sustainability initiatives in Denmark, the climate plan from the Danish Society of Engineers is described. The second part of the paper discusses Danish sustainable housing strategies focusing on new houses and refurbishment of existing houses. Finally some recent experiences from a local climate cooperation between a technical university, a municipal administration and the local branch of a national environmental organisation is presented.

Theoretical approaches to analyses of sustainable housing as innovation processes

This section presents a number of theoretical approaches, which can be used in the analyses of sustainable housing and other types of sustainable initiatives. Examples of the use of the approaches as part of analysing sustainable housing are given as part of the presentation of the concepts, based on (Jørgensen & Jensen, 2006).

Ideally an important element in the analyses (but also in the planning) of sustainable housing projects should be the present or future occupants' *use* of the houses. The use should be seen as an interaction between the occupants, the houses and the infrastructures. Gram-Hanssen and Jensen (2005) suggest applying a *system* metaphor to housing projects. Houses are seen as social-technical systems with focus on the links between the houses' physical artefacts, the institutions of housing (aspects of for example loans, ownership etc.) and the surrounding environments, including the infrastructures for water, electricity etc.

Rohracher (2005) points also in a study of user experience with Austrian energy-efficient buildings to the needs for analyses of user experience and for the integration hereof in design. As an example Rohracher (2003) discusses the changes in the role of windows and ventilation systems in low-energy houses. One of the issues in the introduction of so-called controlled ventilation in Austria was the question of whether or not people should be restricted in opening windows. Planners and architects acknowledge the wish of occupants (dwellers) to open the windows whenever they like

and stress the fact that closed windows are not at all necessary, even if it would improve the performance of the ventilation system. However, planners and architects installed windows which could be opened but could not be tilted in order to make it less easy to forget to close the windows. Users became aware of the intentions to prescribe their behaviour and found ways to override the system. Some designers gave way to user pressure, and started putting more emphasis on different features of the ventilation system (higher capacity, autonomy of control and system performance under less optimal conditions) and thereby turning the original engineering-oriented concept into a more user-oriented concept (Rohracher 2003).

Lie & Sørensen (1996) calls the processes by which technologies are made to work (or not work) and are given meaning by individuals and collectives *domestication*. The concept emphasises the active role of users in defining the use and significance of technologies in everyday life through acquisition, placement, interpretation and integration. In analyses of the domestication of sustainable houses one aspect should be the interaction between the so-called *script* (Akrich 1992) developed in the planning by architects, planners etc. (could be understood as a kind of manuscript for future use of a house or a technology), and the roles it devotes to technology, user and context, *and* the later, actual use (the so-called *de-scription)* by the users through the domestication of the house or technology.

The planning and use of houses may also be seen as an interaction between different types of competence, for example architecture competence, construction competence, environmental competence and user competence. Wenger (1998) defines *communities of practice* as shared histories of learning, which have a joint activity, a mutual engagement and a shared repertoire (of tools, artefacts, stories etc.). In the planning of sustainable housing projects we have seen different types of communities of practice involved. In one project construction companies, citizens wanting to build sustainable houses and a local environmental advice centre offering expertise to construction companies and the local municipal administration were involved. Wenger (1998) mentions two types of connections between different communities of practice *boundary objects* (artefacts, documents, terms, concepts etc.) and *brokers* (people who can introduce elements of one practice into another). In a recent Danish sustainable housing project the international criteria for obtaining an eco-label on one-family houses and the new national construction guidelines for energy consumption of houses were boundary objects in the dialogue between a green consultant (acting as broker) in a local environmental advice centre and construction companies in the planning of the houses (Jørgensen et al, 2009). Communities of practice may also develop among the occupants within sustainable housing projects.

Short introduction to some recent characteristics of the Danish society

After the Second World War, Denmark developed from an agricultural economy into an industrial economy with a variety of products and a service sector. In addition to the traditional sectors with large companies in the shipping, meat, trade and brewery sectors mergers led to bigger companies in engineering, pharmaceutical, agricultural machinery, and tourism and food industries. However, the basic structure of the economy, dominated by small and medium-sized enterprise, has remained largely intact. Denmark ranks very high among European countries in terms of the main economic indicators, like GDP (Denmark Case Study, 2004).

Important environmental issues are air pollution, mainly from vehicle and power plant emissions, nitrogen and phosphorus pollution, drinking and surface water becoming polluted from animal waste and pesticides. In 1992, Denmark was the first country in the EU to introduce a tax on CO2. Denmark now covers around 20 % of its electricity needs from wind power and is also one of the world's leading countries in the use of combined heat and power generation as well as in harnessing energy from biomass (Denmark Case Study, 2004).

The present Danish liberal-conservative Government's Programs focuses on growth, welfare and renewal. The priorities include impeding the tax burden, reforming the health system, pensions and maternity benefits and financing additional expenditure in these areas through cuts in development aid and in environmental programs. After the government came into power 2001, replacing a social democratic one, the environmental policy is based on cost-efficiency. Among the most important policy changes were the cancellation of several large offshore wind farms, and large cuts in economic support for national and international environmental projects. Local authorities play an important role because of their political weight and relative independence. Local Agenda 21 initiatives are one of the local multipliers for sustainable development issues and their implementation (Denmark Case Study, 2004).

Future Climate – the climate plan from the Danish Society of Engineers

In order to put pressure on the Danish government's weakly developed climate strategy the Danish Society of Engineers presented in 2009 a proposal for a Danish climate plan with focus on the combination of increased use of renewable energy and a strengthened focus on energy savings. The plan, which enables a 90% reduction of the Danish climate impact in 2050 through this combination of overall strategies, focuses on the energy system, agriculture and food, industry, housing and buildings, transportation, and climate adaptation (Danish Society of Engineers 2009).

The IDA Climate Plan 2050 is based on a strategy whereby Denmark makes ambitious investments in developing the Danish energy system and infrastructure, and in the longer term enjoys the benefits of these investments. The starting point is that it will become more and more expensive to reduce greenhouse gas emissions for each year that passes before Denmark seriously begins its investments and introduces the necessary regulatory measures. The plan shows how the energy-related costs could change from primarily costs for fossil fuel to mainly investments in renewable energy technologies and energy refurbishment of existing buildings etc. (see figure 1). Figure 2 shows the big differences between the projected energy composition in the Danish Energy Agency's projections and in the Danish Society of Engineers climate plan 2050. Figure 3 shows the overall flows of energy production and consumption in the 2050 vision in the climate plan. Both figures show the big future role of biomass in the climate plan, where around 60% of the energy in 2050 is supposed to come from biomass. It will be a major challenge to democracy and sustainability to integrate the necessary concerns for nature, environment, health and public involvement.

Need for flexible approaches in the future energy system
Reduction of the climate impact needs a combined focus on energy supply and energy consumption where electricity, heating, cooling etc. are considered. In the future energy production and storage need to be much more decentralised in order to enable a substantial increase in the use of renewable energy. Especially the need to store electricity from wind turbines in periods with high production

and low consumption calls upon development of new approaches to the societal energy system, where for example batteries for electrical cars is acting as a big number of local energy storage facilities and the electricity supply for refrigerators etc. in households is turned off for short periods

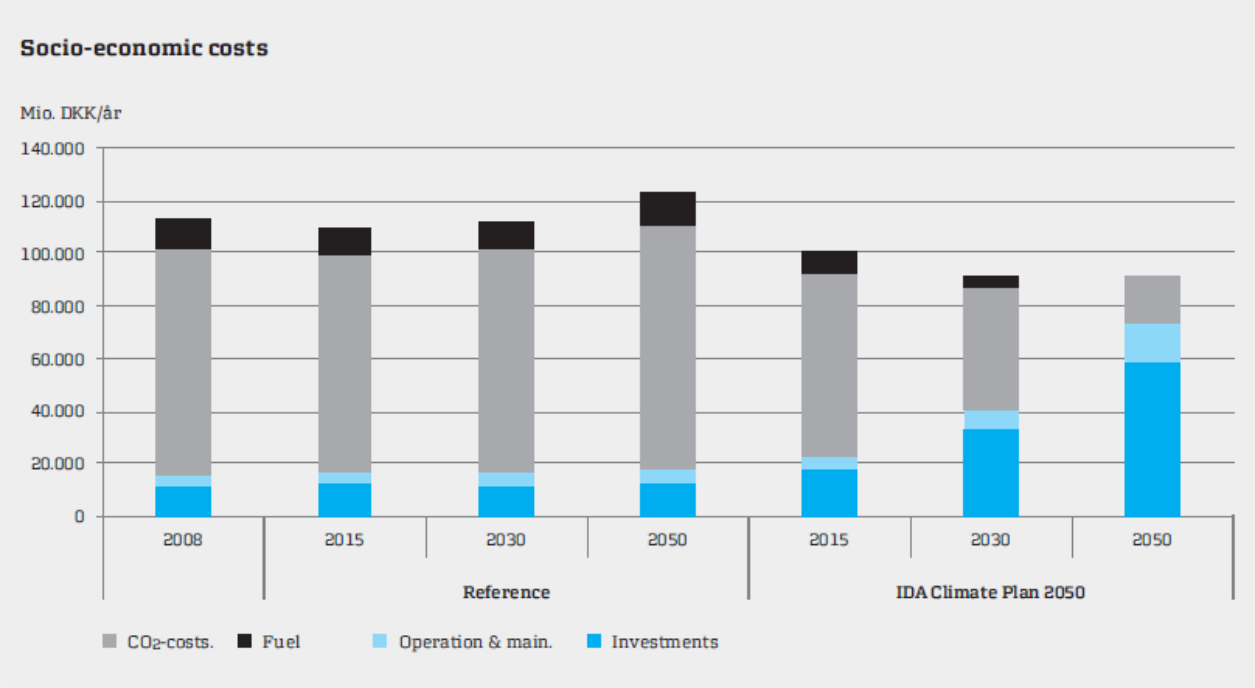

Figure 1: Socioeconomic expenses for the Danish Energy Agency's projections and The Danish Society of Engineers' climate plan 2050 respectively (Danish Society of Engineers, 2009)

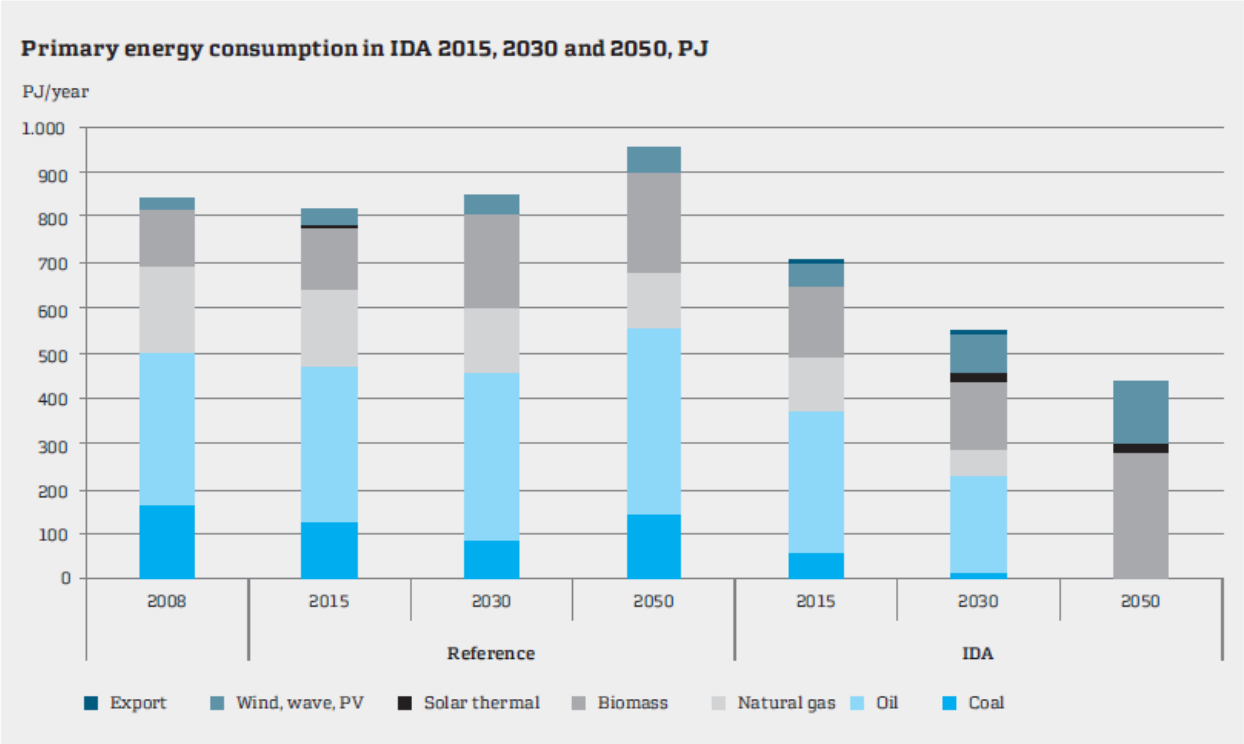

Figure 2: The energy composition in the Danish Energy Agency's projections and in The Danish Society of Engineers' climate plan 2050 respectively (Danish Society of Engineers, 2009)

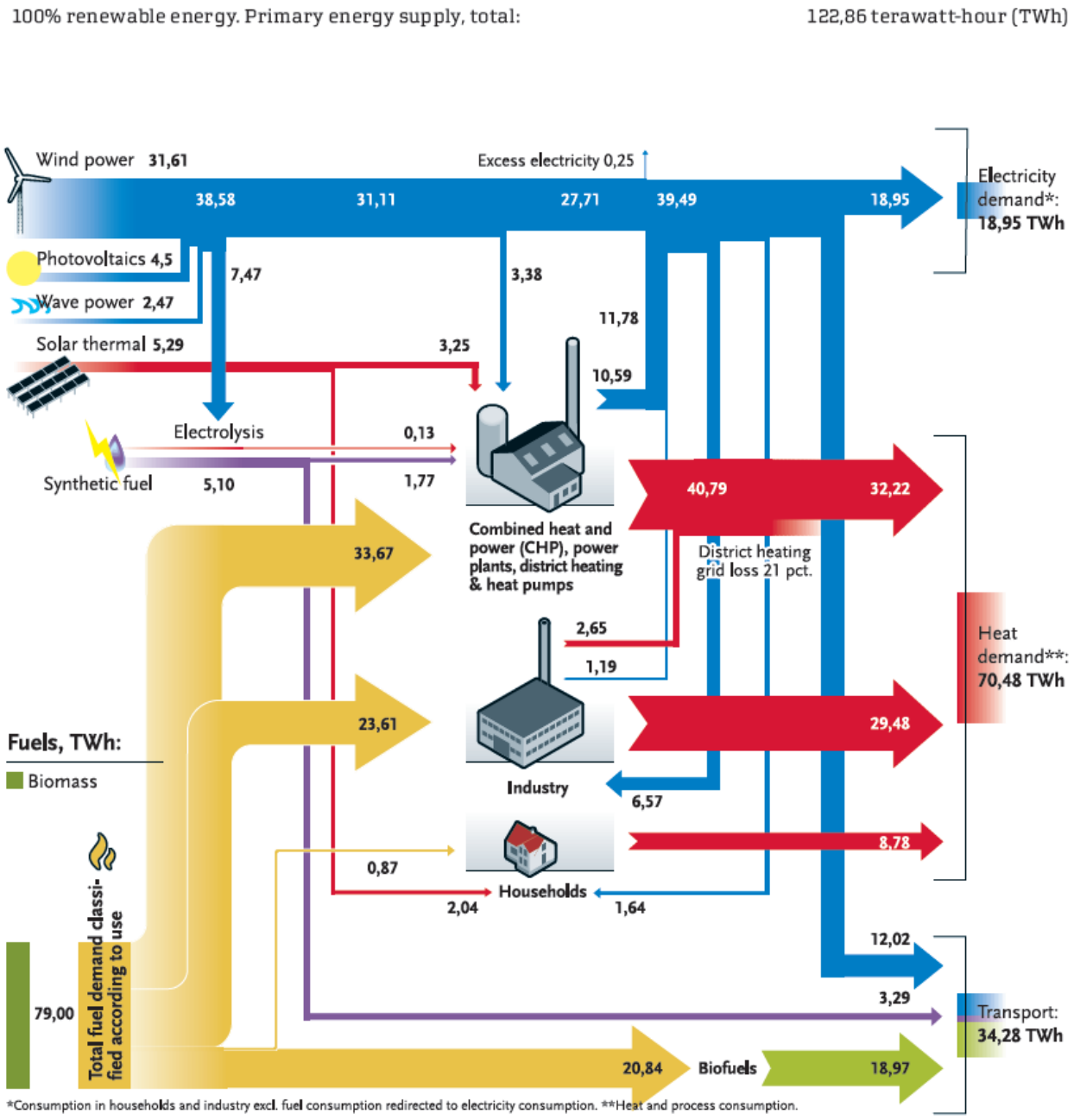

Figure 3: Overview of the energy sources and the energy consumption areas in the vision for 2050 in the Danish Society of Engineers' Climate Plan (2009)

when other electricity needs are high in order to reduce the need for extra power plants. This concept for the electricity system is often called an 'intelligent grid' (see for example Morgan et al, 2009) or a 'smart grid', which is an electricity network that can integrate the actions of all users connected to it: generators, consumers and those that do both. The aim is to deliver sustainable, economic and secure electricity supplies. The 'intelligent grid' concept is not only used in sustainable energy visions. Also intelligent grids with nuclear power based grids have been proposed by energy stakeholders.

Heating for mass housing is also a challenge in the transition from a fossil energy system to a renewable energy system. The number of square metres in buildings has increased, but through a combination of room heating savings and expansion of co-produced electricity and heating (combined heat and power plants, CHP) the fuel consumption and the CO2 emissions for residential heating in Denmark have at the same time fallen substantially. At the same time oil for heating has been replaced with other fuels and gradually also more renewable energy has been introduced.

Flexible energy consumption is not only a possibility in the electricity system. There are also good arguments for district heating consumption to be made flexible, since hot water containers and under-floor heating can be used very well as energy stores and, due to the thermal inertia, are well suited to short term interruptions of supply. At the moment, around 40 % of Danish homes are heated by natural gas, oil and biomass boilers and electric heating also in the vicinity of areas that have district heating. The climate plan from the Danish Society of Engineers (2009) suggests that in 2030 an expansion of the district heating system should cover 70 % of the total building stock. It is furthermore appropriate to consider whether renewable energy technologies can be integrated into buildings that are located far from a district heating station. The advantage of this solution is that energy is produced close to where it will be used, which minimizes loss from the supply network, e.g. in summer months. Demonstration projects are currently underway which show ways in which renewable energy can be integrated, both in the form of large scale facilities in district heating stations and in small scale facilities closer to buildings.

Solar thermal technology is a simple technology that has been tried and tested over the course of many years and has now reached the stage of its development at which solutions become standard solutions. Thermal pumps and solar thermal pumps can replace traditional heating systems, such as oil-fired central heating or natural gas in energy-efficient buildings outside the district heating system. The advantage of using thermal pumps in existing buildings is that fossil fuels are superseded by electricity that can be produced by renewable energy sources. The climate plan assumes that 5 % of the electricity consumption of buildings is covered by solar cells integrated into buildings by 2050 (Danish Society of Engineers 2009).

Housing and buildings in the climate plan

The visions and recommendations on housing and buildings in the climate plan focus both on existing and new houses and buildings with refurbishment of existing houses and buildings as the main contribution to the future reduction of climate impact. The objectives and initiatives in relation to housing and buildings in 2020, 2030 and 2050 are shown underneath (Danish Society of Engineers, 2009).

Objectives and initiatives until 2020:

- In the period up to 2020, 75 % of the most poorly insulated walls, roofs and floors will be renovated and windows replaced. This will result in a saving of 18 PJ in 2015 and 37 PJ in 2020
- Electricity consumption will be reduced by 25 % compared to 2008

Objectives and initiatives until 2030:

- From 2020, new buildings will be “energy producing” according to BOLIG+ standards (a new zero emission building concept).

- Between 2020 and 2030, walls, roofs and floors that are poorly insulated according to current good, average standards will be renovated. This will result in a saving of 21 PJ. Renovation of technical installations between 2010 and 2030 will result in a saving of 20 PJ. Together with activities in the period between 2010 and 2020, by 2030 the total annual saving will amount to 78 PJ.
- Buildings that are not included in the district heating system will be made energy-neutral by promoting the use of renewable energy in buildings.
- The district heating system will be extended and cover approximately 70 % of the total existing building stock.
- Electricity consumption will be reduced by 50 % compared to 2008.

Objectives and initiatives until 2050:

- The energy consumption in buildings has been reduced and buildings outside of the district heating systems are CO2 neutral. Buildings included in the district heating system will receive energy from renewable energy or waste heat.

The climate plan points to the need for the creation of incentives in order to ensure that investments in energy refurbishment are made. This can be done by providing public grants for renovation, favourable loans, differentiated taxation and consumer information. The energy labelling scheme for buildings must be further developed and used to identify the most viable renovation solutions. The scheme can also be used as a tool in connection with loans (Danish Society of Engineers 2009).

Visions and recommendations for transportation and food in the climate plan
Also food production and consumption and transportation are included in the climate plan. The main elements in the transportation part of the plan are (Danish Society of Engineers 2009):

- Reducing the transportation needs and integrating renewable energy
- Re-organisation of sections of road traffic into public transport, bicycles and walking
- Car taxes converted from fixed to consumption-dependent taxes
- Road pricing system and tolls for entering bigger cities
- Municipal plans supporting urban densification rather than spreading
- Re-organisation of goods transport from road to rail

The food and agriculture part of the plan proposes reduced food waste at the household level, dietary changes towards less consumption of animal products and higher consumption of seasonal vegetable products, and a more sustainable agriculture, including continued transition of conventional agriculture into organic agriculture (Danish Society of Engineers 2009).

Changes in Danish strategies for sustainable housing

This section discusses the recent strategies for sustainable housing in Denmark. (Gram-Hanssen & Jensen, 2005) highlight four different approaches to sustainable housing in Denmark during the last 35 years:

- Green buildings as energy-saving devices as a strategy after the oil crisis in 1973 focusing on technologies and governmental regulation supporting the implementation
- Ecological alternatives, often as new rural settlements, emerging from the grassroots level as a radical critique of the modern society

- Subsidized large-scale urban projects as a public drive towards green buildings following the Brundtland report, primarily as projects under the Danish Urban Renewal Act
- Green buildings in a market approach, where green labels recently have been developed to give consumers a role in the development of sustainable buildings as individual consumer products, rather than basing the development on public subsidies.

One of the new rural settlements mentioned as one of the strategies above is the Hjortshøj cooperative community, where 8 groups of houses have been established or planned since the beginning of the 1990s with a mixture of forms of ownership (private, co-operative renting) and including community houses and local workplaces (www.andelssamfundet.dk). There has been a long phase of gaining building permits and conducting construction planning. In order to show the type of initiatives, the sustainable initiatives in one of the eight groups are described:

- Passive solar heating by having an enclosed glass room in connection with the rest of the house.
- Outer walls covered with red cedar wood and insulated with granulated paper
- Common walls between the houses made up of compressed clay bricks from a mixture of the clay dug up from the surrounding area.
- Wood chip furnace supplying central heating.

One of the large-scale urban projects under the Danish Urban Renewal Act was Hestestaldskarreen in Copenhagen, which comprises of 15 different houses with their own resident boards, who developed a project together with a municipal adviser. The project was based on an integration of urban ecology initiatives and urban renewal of the buildingd. The urban ecology initiatives included construction of joint rain water collection tanks for flushing the toilets (not used by all houses) and a central heating system for most of the houses. Lighting in the yard, pumps, common laundry etc. is powered by solar cells on some roofs and facades (http://www.hestestalden.net/oekologi.html).

Jensen and Gram-Hanssen (2008) discuss the recent development within sustainable housing in Denmark as green buildings in a market approach by looking at the roles of

- new types of cooperation and roles for actors in the planning and definition of sustainable buildings
- standards, norms, and tools to define and legitimize the sustainability of buildings
- visibility and measurement of energy and material flows, with the purpose of integrating concerns about this into the existing institutions and decision-making processes

Jensen and Gram-Hanssen (2008) see new cooperative relations developing between different types of actors that earlier have not cooperated, such as civil society organisations and the professional construction industry (consultants, contractors, producers and others). Jensen and Gram-Hanssen also see an increasing degree of voluntary involvement in defining goals and initiatives within sustainable housing. However, the obtained results are not sufficient. The main-stream part of the construction sector has not yet shown ability and willingness to develop convincing objectives for sustainability. Therefore the traditional top-down regulation of energy efficiency through the Danish Building Regulations still gives the most significant and widespread improvements for new buildings and actually also major renewal projects of existing buildings. The Danish Building Regulations have had energy savings as the main theme since 1982. Efficiency improvements in heating

consumption of buildings are an essential element of the development of higher demands in the Building Regulation (Jensen & Gram-Hanssen, 2008).

Demands for documentation and quantitative objectives for sustainable housing are increasingly gaining ground in Denmark. An important discussion is whether increasing use of standards and assessment tools will lead to agreement about what sustainable building is. No standard has come through as the one and only standard. Instead there are a number of different tools and assessment methods on the market that reflect a plurality in the perception of sustainable buildings in different building projects.

Visibility of consumption is another element in the recent development. Individual payment of the resource consumption of households can lead to energy savings and thereby environmental benefits. As mentioned earlier, the recent tendency is to build sustainable housing that can sell on market terms to ordinary people. This means that sustainability is made more invisible so the sustainable buildings look like ordinary buildings, which on the other hand might hide the aspects of sustainability of the buildings to a family if they buy such a house (Jenssen and Gram-Hanssen, 2008).

Jensen and Gram-Hanssen argue (2008) that there is still an important role for the grassroots to play because the top-down Buildings Regulations is not able to stop the growing housing consumption in terms of square meter per person, but also growing housing prices which force people to live far from their workplaces and thus depend on long daily commutes to the workplace.

The shaping of recent sustainable housing concepts in Denmark

A research project focusing on the experiences from some recent Danish sustainable housing projects is conducted by Department of Management Engineering at Technical University of Denmark and the National Building Research Institute at Aalborg University 2007-2010. Six sustainable housing projects have been analyzed in order to develop an understanding of the mechanisms in planning and use of such housing projects and develop proposals for future research, innovation, and diffusion within the field. The projects are seen as part of an ongoing interaction between environmental discourses and environmental strategies, the dynamics of the construction sector and the dynamics of municipalities. The project addresses the following topics in the analyses of the case studies (Jørgensen et al, 2009):

- What type of actors are initiating this kind of housing projects and why?
- What type of actors and entities are involved in the planning of the houses and which interactions take place between the different types of actors and entities and between different types of competencies? How much are these relations building on existing business relations and how much are the relations set up for the specific planning processes?
- What role has standards played in the planning of the houses?
- What issues in relation to resource consumption and environmental impact have been addressed? What strategies were developed for these issues?

The case studies of housing projects represent a variety in relation to a) the present stage (planning, construction, use) and b) different ways of organizing the planning process, especially with respect to the role of municipalities, future occupants and environmental intermediaries. All analyzed projects are based on one-family houses or semi-detached houses.

The project has identified a number of new initiators to sustainable housing projects:

- municipal administrative staff in order to influence future construction of houses in the local area
- local green intermediary in order to make sustainable houses which may attract ordinary citizens
- building component company in order to initiate development of new building concepts
- co-operative housing association to support development of more sustainable housing concepts

The different initiators have tried to enrol other stakeholders in their initiatives and establish housing projects. The municipal administrative staff and the local green intermediary were able to enrol the city councils and also enrol construction companies, which wanted to construct house and citizens who wanted to buy houses. However, some projects have also experienced lack of enrolment of important stakeholders. Problems engaging either construction companies or citizens to some projects show the role of demand and supply within the housing area. Some projects have had problems finding citizens who were willing to buy a house in an area allocated for sustainable housing when the housing market suddenly was characterised by a surplus of houses for sale and in one project no construction companies were willing to accept the guidelines for a housing project, when a piece of land was put for sale with demands for the companies, which wanted to build on the land.

Different types of standards have influenced the shaping of the projects. The new Danish construction guidelines for new houses with stronger demands for the energy consumption and efficiency have influenced some projects. The new Nordic eco-labelling guidelines for family houses has been developed and tested as part of one of these case studies. Other types of standards that have played a role are local guidelines for housing projects and internal company standards for houses, which imply that a construction company prefers to convince existing suppliers to change their products than to include new suppliers in their supply chain. A concept that has influenced two of the projects is the so-called passive house concept, where houses are supposed to have rather low energy consumption. The strongest focus among sustainability aspects has been on energy consumption. Some cases have also focus on reduction of environmental risk from construction materials and reduced water consumption.

The analysed projects represent different levels of innovation with respect to building technology. One company based on standardized houses wanted as little innovation as possible in order not to have to change suppliers and change their production equipment. One project involved foreign designers because they found Danish designers too traditional. These findings show the need for studies of the diffusion of sustainable housing technologies: whether and by which mechanisms such diffusion takes place.

The project findings show also the need for detailed studies of the citizens' actual domestication of new sustainable houses or description of the developed script for a housing project, in order to understand those processes by which technologies are made to work (or not work) and are given meaning by households through acquisition, placement, interpretation and integration. Achieving the predicted low energy consumption was difficult in a project where the houses had been in use for a period. Another project showed attempts from the construction company to ensure the

predicted low energy consumption by providing the instructions for use and maintenance, which are demanded as part of the Nordic eco-labeling criteria for one-family houses (Jørgensen et al, 2009).

Energy refurbishment of existing housing and buildings

It is not enough to focus on the few new, more energy efficient houses. 75% of the buildings which we live in 30 years from now will be buildings that already exist today. Therefore refurbishment of *existing* buildings should be the main focus in sustainable housing strategies, including climate strategies for housing. It may be 'dangerous' if too much focus is put on the development of new housing concepts, if these concepts are not applicable to existing houses.

The focus on energy refurbishment of existing housing started in Denmark in the 1970's as part of the energy strategy following the so-called oil crisis in 1973, when the Middle East oil producing countries increased the oil prices. The recent years the focus on energy refurbishment has increased in Denmark. Several actors in the Danish construction industry and building materials manufacturers have conducted demonstration projects within energy refurbishment combined with renovation. A new national centre for energy savings in buildings has been launched recently and energy refurbishment plays a big role in the different climate and energy plans, which different civil society organisations have developed the recent years, including, as earlier mentioned, the climate plan from the Danish Society of Engineers.

There are examples of refurbishment projects initiated by different types of stakeholders of older detached houses from around 1930, single-family houses from 1960 – 1980 and apartment blocks from 1970 (Danish Society of Engineers 2009). A refurbishment project on a one-family house from 1970s includes (http://www.rockwool.dk/inspiration/renovering+af+70%e2%80%99er+hus):

- Insulation of facade, foundation and loft
- Renovation of part of the roof
- Renovation and change of windows and external doors
- Change of gas boiler
- Installing ventilation system

It is not clear whether the ventilation system includes re-use of energy through heat exchange between the supply air and the exhaust air.

In order to enable the future energy refurbishment it is necessary to develop concepts for the different types of housing, including different types of ownership and different building styles and house types. It can be difficult to finance future energy refurbishment in the non-profit residential sector due to the upper limit to housing costs per m2 in this type of housing. Furthermore, the possible co-funding available from the National Building Fund, which the residents in this type of housing contribute to in order to enable refurbishment projects, is limited since the national government has used part of the assets in the Fund for building new houses. Also privately owned semi-detached houses may be a challenge to the future energy refurbishment since the houses ideally should be refurbished jointly in order to ensure aesthetical values of the houses. However, since the single housing is privately owned it is at the moment not possible to force the single owners to invest in refurbishment. A recent project tried to develop a concept for joint refurbishment of a group of old semi-detached houses in the Lyngby-Taarbæk municipality in the

northern part of Greater Copenhagen, which should show that it would be more economic feasible for the house owners to conduct the refurbishment as a joint project. The project involved the local municipal administration, the local house owners' association, an energy company, construction companies and Technical University of Denmark. However, since the house owners did not find the overall plans, which were developed, sufficiently economic feasible, the concepts were not developed into more detailed construction plans.

Local climate activities in co-operation between municipality, civil society and university

Also other urban activities with impact on environment could be in focus in urban environmental projects, like transportation and food consumption. It is often said that 'beef, car and housing' are the big contributors to environmental impacts, including climate impact. Along this line, the Science Shop at DTU has since 2007 co-operated with the local municipal administration of Lyngby-Taarbæk and the local branch of an environmental NGO about strategies for reducing climate impact. The co-operation was initiated by a proposal to the Science Shop from the municipal administration. Since the Science Shop requests civil society involvement in projects it was proposed to involve the local branch of the environmental NGO. The starting point was topics developed by the administration and the NGO together and announced to students as part of the Science Shop project supply.

Some projects have focused on municipal activities (buildings), while others have focused on activities where private and public decisions interact (the staff's transportation to and from work; the public food supply for elderly people and for municipal employees). Also private activities within the municipality as geographic area have been in focus, like climate impact from local businesses and houses.

By focusing on the activities *causing* the climate impact and strategies for *reducing* the climate impact the projects ideally become relevant for all parts of the technical university. The activities are initiated and co-ordinated by a group with members from municipal administration, the local NGO and the Science Shop. All projects have involved student projects carried out as part of their curricula, but most projects have also contributed to ongoing research activities. The projects up till now have focused on the follow topics:

- the municipal food supply to city hall staff through the canteens and to elderly citizens,
- the municipal employees' transportation habits, including developing proposals for new biking concepts
- the municipal energy management and energy saving activities,
- local businesses' climate impact
- the energy refurbishment of existing private-owned semi-detached houses (as mentioned earlier in the paper)

The knowledge production has in some projects mainly been based on academic work, but joint knowledge production with civil society has taken place in some projects. Results have been published locally and some of the results also nationally. Especially the food projects have got

national interest. As an example of a project result, figure 4 shows a CO2 pyramid, which illustrates the difference between the climate impact, expressed as so-called CO2 equivalents, within and between different groups of food. The pyramid was developed by the students in dialogue wuth the municipal kitchen managers and the supervisor as a tool for the staff in the municipal food production for elderly citizens in order to make it easy for the kitchen managers to exchange one food ingredient with another ingredient with less climate impact. The pyramid

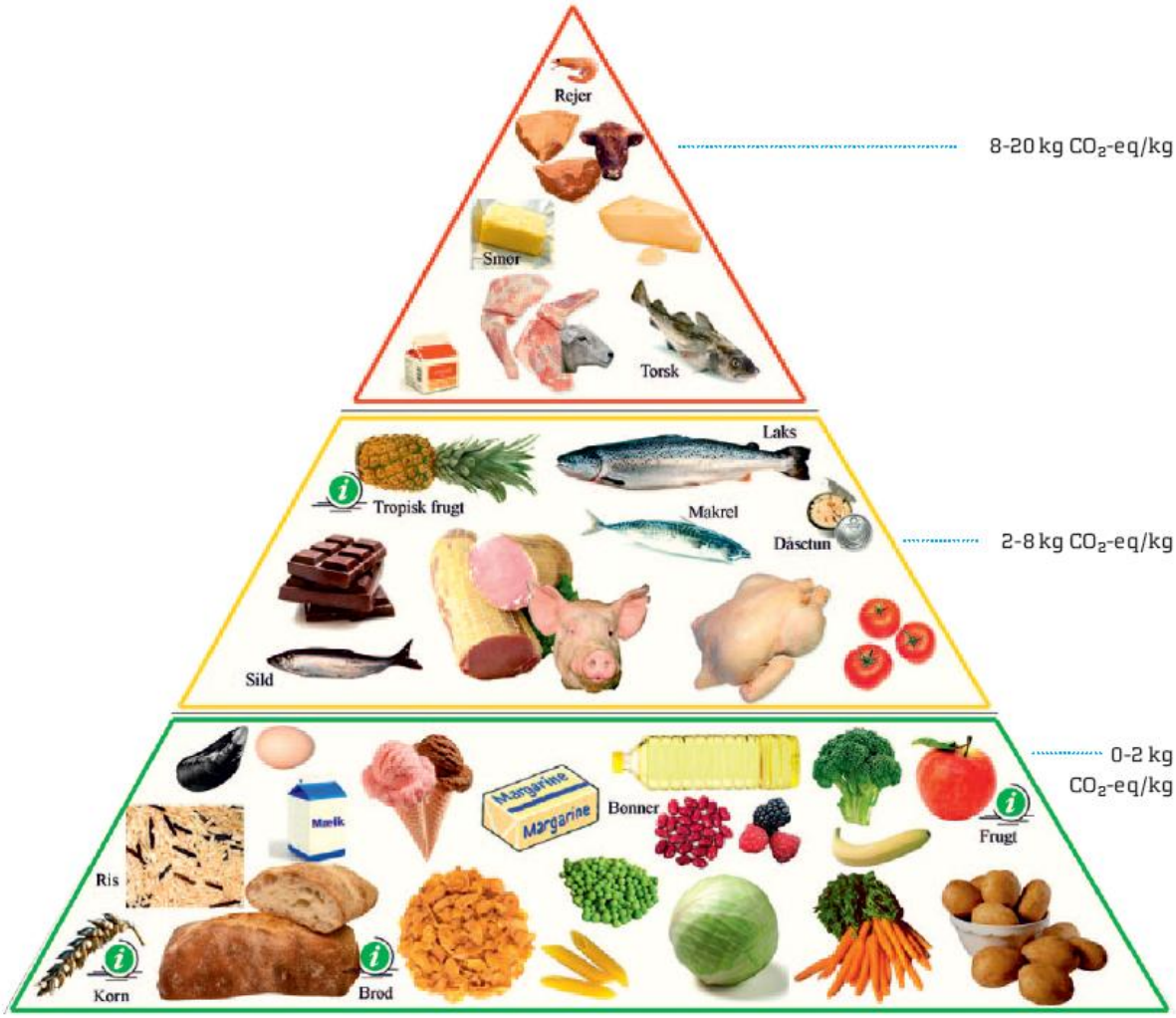

Figure 4: Pyramid with different groups of food and food products organised according to their climate impact expressed as CO2 equivalents. The higher a product is placed in the pyramid, the higher is the climate impact per kilogramme food. (Updated version of figure from (Lund & Madsen, 2008), here reproduced from (Danish Society of Engineers, 2009))[1]

[1] The Danish names of the food in the pyramid translated to English, organized according to the different horizontal zones of the pyramid: Red zone: Rejer = scrimps. Smør = butter Torsk = cod. Yellow zone: Tropisk frugt = tropical fruit (by air plane). Laks = salmon. Makrel = mackerel. Dåsetun = canned tuna. Sild = herring. Green zone: Frugt = fruit transported by surface transportation. Ris = rice (European average) Korn = grain. Brød = bread. An 'i' in a green circle besides a food product implies that the climate impact shown is calculated as an average of the climate impact from a number of related food products.

Co-operation about environmental impacts of municipal investments may be an up-coming activity in the climate cooperation between the municipality, the local environmental NGO and the university.

References

Akrich, M. The De-scription of Technical Objects. In: Bijker, W.E. and Law, J, editors. Shaping Technology/Building Society: Studies in Sociotechnical Change. Cambridge, MA: MIT Press, 1992, 205-224

Denmark Case Study. Analysis of National Strategies for Sustainable Development
From "National Strategies for Sustainable Development: Challenges, Approaches, and Innovations Based on a 19-country Analysis", 2004. Available at
www.iisd.org/pdf/2004/measure_sdsip_denmark.pdf (accessed 14 April 2010)

Danish Society of Engineers. The IDA Climate Plan 2050. Future Climate Engineering Solutions, Copenhagen 2009

Gram-Hanssen, K. & Jensen, J.O. Green Buildings in Denmark – From radical ecology to consumer oriented market approaches? In: Sustainable Architectures. Cultures and Natures in Europe and North America. Spon Press, 2005, 165-184

Guy, S. & Moore, S.A. (eds) Sustainable Architectures. Cultures and Natures in Europe and North America. Spon Press, 2005

Jensen, J.O. & Gram-Hanssen, K. Ecological modernization of sustainable buildings: a Danish perspective, In: Building Research & Information, Vol. 36, No. 2, 2008, 146 - 158

Jørgensen, M.S. & Jensen, J.O.: Studying Innovation and Participatory Design in Planning and Use of Sustainable Houses, Working paper Department of Manufacturing Engineering and Management and Department of Civil Engineering, Technical University of Denmark, 2006, 5 pp.

Jørgensen, M.S.; Lauridsen, E.H.; Quizau, M.; Jensen, J.O.; Elle, M and Bilfeldt, A. The shaping of new sustainable housing concepts in Denmark. Abstract for the JAOCC conference, Aalborg, 8-10 June 2009, 2 pp.

Lie, M. & Sørensen, K.H. Making Technology our Own? Domesticating Technology into Everyday Life, Oslo, Scandinavian University Press, 1996

Lund P.G. &. Madsen. L.K. Philip G. Lund & Lars K. Madsen. Måltiders klimapåvirkning (In Danish) (Climate Impact of Meals), Student Project, DTU Management Engineering, 2008

Morgan, M.G.; Apt, J.; Lave, L.B.; Ilic, M.D.: Marvin Sirbu, M. & Peha, J.M.: The many meanings of "Smart Grid", A briefing note from the Department of Engineering and Public Policy, Carnegie Mellon University, USA. Available at http://www.leonardo-energy.org/what-definition-smart-grid (accessed 14 June 2010)

Rohracher, H. The Role of Users in the Social Shaping of Environmental Technologies, In: Innovation, Vol. 16, No. 2, 2003, 177 - 192

Rohracher, H. Social research on energy-efficient building technologies. Towards a sociotechnical integration. In: Sustainable Architectures. Cultures and Natures in Europe and North America. Spon Press, 2005, 201-218

Wenger, E. Communities of Practice. Learning, Meaning and Identity. Cambridge University Press, 1998

Links:

www.andelssamfundet.dk (accessed 14 June 2010)

http://www.hestestalden.net/oekologi.html (accessed 14 June 2010)

http://www.rockwool.dk/inspiration/renovering+af+70%e2%80%99er+hus (accessed 14 June 2010)